US pioneers restoration of deep water corals damaged by country's worst oil spill

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Body

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Scientists are conducting a pioneering large-scale deep-sea coral restoration in the Gulf of Mexico following the 2010 Deepwater Horizon oil spill, which damaged 1,994 square kilometers (770 square miles) of seafloor habitat.

Underwater robots and Navy divers using specialized gear to work at depths up to 100 meters (328 feet) plant coral fragments on the ocean floor, while labs in Texas, South Carolina and Florida grow corals in tanks for future transplantation.

The novel eight-year, multi-million-dollar project has achieved milestones including high deepwater coral survival rates at sea and the first successful spawning of deep-sea corals in captivity, which produced more than 1,000 baby corals.

The restoration faces ongoing threats from climate change, commercial fishing, agricultural runoff and potential future oil spills, with nearly 1,000 spills occurring in U.S. waters in 2021 and 2022 alone.

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In the twilight depths of the Gulf of Mexico, about as deep down as a football field is long, U.S. Navy divers carefully snip small branches of corals with gloved hands. Their voices crackle through communication systems to the ship above, distorted to high-pitched tones by the helium mixtures they breathe.

'These guys, they're tough, tough Navy dudes that are saturation experimental divers,' Chris Gardner, a U.S. government fisheries biologist on the team that oversees deepwater coral restoration in the Gulf, told Mongabay. 'But the audio can be a little goofy because they're breathing mostly helium. So, there's definitely some Mickey Mouse effects going on.'

A US Navy diver descends to the twilight zone with a diving bell, which allows divers to go deep beyond recreational diving limits. Image courtesy of NOAA/C-Innovation, LLC.

The surreal scene, of highly trained Navy divers speaking in cartoon voices while performing precise underwater surgery on orange and purple coral colonies, illustrates the extraordinary measures underway to restore ecosystems damaged by the British Petroleum (BP) Deepwater Horizon spill, the worst oil spill in U.S. history.

This work marks one of the world's first attempts at deep-sea coral restoration, and the largest to date, according to the U.S. National Oceanic and Atmospheric Administration (NOAA), the agency in charge of the restoration.

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Ancient forests of the deep

Beneath the Gulf's wind-whipped surface, down where the sunlight dims and vanishes, live slow-growing coral communities that rival old-growth forests. These underwater ecosystems have existed for millennia, creating complex habitats that support entire food webs of life above.

'Some of the deep-water corals can live for 2,000 years or more,' said Gardner, who works for NOAA's Southeast Fisheries Science Center with multiple offices across the southeastern U.S. Destroying them, he said, 'it's not like cutting a pine tree that can be replaced in 20 years. This is something that we're going to be judged for generations from now.'

An ancient Swiftia exserta coral in the deep Gulf photographed by a remotely operated vehicle as part of the MDBC project. Image courtesy of NOAA/Marine Applied Research and Exploration.

These corals live in the mesophotic or 'twilight' zone, roughly 50-300 meters (150-1,000 feet) deep, where little light reaches. In the perpetual twilight, orange Swiftia exserta corals fan out like grasping flames, Muricea pendula's red branches dance in the current and purple Thesea nivea corals form underwater gardens.

Video footage from the deep underwater expeditions to the coral shows a world teeming with life. Schools of fish, small and large, dart among rocks, corals, sponges and sand. Basket stars and feather stars, resembling creatures from a science fiction film, latch onto coral branches as the odd eel peeks out its head. Occasionally, an octopus waddles through the scene.

'These animals are never going to come to the surface and say hello. You're never going to know that they exist,' Caroline Emch-Wei, curator of aquatic husbandry at Audubon Aquarium in New Orleans, told Mongabay. 'You take the average person and say, 'Did you know there's corals in the deep Gulf?' They're going to say no.'

Mesophotic habitats see little sunlight yet are still home to a diverse collection of animals, including corals. Image courtesy of NOAA/Marine Applied Research and Exploration.

As one of the main habitat-forming creatures down in the Gulf, corals grow in giant fields, providing the base ecosystem for regional fisheries. The three-dimensional structure they create provides shelter from predators and currents, creating safe zones where young fish can develop before venturing into open water.

'Corals are not only a food source for a lot of animals, but they're also a habitat. So, a lot of animals will use them as a home for their nursery for their young,' Emch-Wei said.

The connection between these deep-sea corals and the seafood on our plates remains largely invisible to consumers, yet it's fundamental to the Gulf's marine economy. These ecosystems support seafood industries worth billions.

Gulf of Mexico mesophotic coral species Swiftia exserta reared in the US Geological Survey's Gainesville, Florida, lab. Image courtesy of Will Jenkins/USGS WARC.

Disaster

The work to restore these deep-water corals began with a catastrophe. Fifteen years ago, on April 20, 2010, the Deepwater Horizon oil rig operated by British Petroleum (BP) exploded, killing 11 workers. The explosion in the Macondo prospect, 66 kilometers (41 miles) off the Louisiana coast, triggered the largest oil spill in U.S. history.

Attempts to contain the blowout failed repeatedly. Day and night for nearly three months, massive quantities of oil poured into the Gulf's water. It took three months to cap the well, which released an estimated 507 million liters (134 million gallons) of oil, enough to fill 200 Olympic swimming pools. The oil didn't just float to the surface in the familiar slick seen in news footage; about a third sank.

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Fireboat crews work to extinguish the burning wreckage of the BP Deepwater Horizon oil platform in 2010. The disaster was one of the worst ecological catastrophes history. Image courtesy of the U.S. Coast Guard.

'When the well broke, oil spewed out under high pressure, in little drops like paint from a spray paint can,' Paul Montagna, a deep-sea expert from the Harte Research Institute, part of Texas A&M University-Corpus Christi, told Mongabay. 'We're pretty sure that 35% of the oil released wound up in the bottom of the ocean.'

The spill damaged more than 1,994 km2 (770 mi2) of deep-sea habitat, an area half the size of Rhode Island, the smallest U.S. state, according to NOAA. Satellite images could track oil on the surface, but underwater, in the dark realm of deep-sea corals, the damage was much harder to track.

'I have seen damage that has occurred as a result of this spill,' said Andrew Davies, a professor of marine biology from the University of Rhode Island. 'The corals generally look like they have missing branches or there's dead tissue, and all you see is the skeleton.'

A remotely operated vehicle collects a sample of the sea fan Muricea pendula in the Gulf of Mexico from the vessel R/V Point Sur in October 2022. Image courtesy of NOAA.

A 2012 study found a coral community 11 km (almost 7 mi) from the wellhead with clear signs of damage. The researchers documented 'widespread signs of stress' including tissue loss, excess mucous and bleaching. They also found brown material containing oil compounds from the Macondo well - the smoking gun linking coral death directly to the spill.

'The corals took a hit,' Gardner said. 'It's pretty heartbreaking to see something that beautiful, that old, just get destroyed by oil.'

Restoration begins

After years of litigation and scientific assessment, BP agreed in 2016 to pay up to $8.8 billion in natural resource damages over 15 years. The settlement, the largest of its kind in U.S. history, supports an array of restoration efforts, including terrestrial and marine habitat restoration and water quality projects.

Officials allocated $273 million to the deep-sea Mesophotic and Deep Benthic Communities (MDBC) restoration research projects. This initiative aims to restore entire ecosystem communities - healthy coral as well as invertebrate and fish communities - focusing on high-density coral sites and other hard-ground areas to create healthy habitats. So far, restoration has occurred in at least five sites, with more planned. The project is spread across about 247,700 km2 (95,600 mi2) in the Gulf of Mexico.

The funding supports four interconnected projects: mapping to find what's down there, assessing the deep benthic habitats, propagating coral and protecting and managing deep ocean habitats.

MDBC scientists and technicians aboard a research vessel working in the Flower Garden Banks National Marine Sanctuary, where some of the coral restoration took place. Image courtesy of Erin Spencer / National Marine Sanctuary Foundation.

The MDBC effort is led by NOAA and the U.S. Department of the Interior, including the U.S. Geological Survey (USGS), and partners with research institutions, aquariums and various nonprofit organizations. Five years into the eight-year project, about half of the $273 million has been allocated.

'We have so many missions going out there so many different scientific disciplines that are all coming together,' Davies said. 'This project gives us an unprecedented opportunity for real collaboration and real exciting science.'

Mapping the deep

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Before restoring corals, scientists needed to know where they grow and have detailed maps of the Gulf seafloor. NOAA and its partners use two primary technologies for this work: autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs).

The AUVs, self-guided torpedo-shaped robots that can work independently for up to 24 hours, map over larger areas, using advanced sensors including multibeam sonar, synthetic aperture sonar and laser scanning systems. They follow preprogrammed routes, methodically scanning the seafloor like underwater lawnmowers covering a vast field.

One of the autonomous underwater vehicles (AUVs) used to map the ocean floor. Image courtesy of Elijah Hall / NOAA

ROVs, tethered robots controlled from ships, go down with cameras to collect detailed images and ground-truth areas identified by the AUVs that may have corals or rock outcroppings that support an abundance of life. Using the camera footage, researchers identified the most damaged coral species and locations to focus limited resources where they would have the greatest impact.

Together, these tools create high-resolution maps with centimeter-level precision, allowing researchers to see details invisible to previous surveys, including small coral colonies, rock outcroppings and subtle seafloor features that create coral habitat.

'We are mapping the Gulf to a level that is practically unprecedented,' Davies said.

Remotely operated vehicles such as the Odysseus are used to ground-truth maps and collect coral fragments in the deep sea. Image courtesy of Sophia Melville / URI Inner Space Center.

The team has mapped about 19,400 km2 (7,500 mi2) of seafloor since the implementation phase began in 2022, an area about the size of Wales, and the mapping will continue for at least another year. The goal is not only to understand where corals are, but what lies in the fields of sand and stone that surround them.

With maps in hand, scientists are taking two approaches to coral restoration: Propagating corals from cuttings in the sea and by breeding them in the lab.

Live octocoral samples collected by technical divers (Left to right: M. pendula, M. pendula, T. nivea, S. exserta, S. exserta). Image courtesy of NOAA Fisheries.

Coral propagation at sea

The ROV, looking like a cross between a bulldozer and a spacecraft, descends into the twilight zone. Pilots watching video feeds aboard the ship above operate the ROV's mechanical arms with surprising delicacy.

An arm extends to collect pieces of healthy coral no bigger than a human hand and place them into a filing cabinet in its belly, one by one. These pieces will be used for propagation; small cuttings will eventually be planted back out like little tree saplings, ready to form new colonies.

The ROV removes less than 10% of any colony, to avoid harming it. Trimming can stimulate growth as well as help spread the coral out to new areas. The goal is to plant more out than what was lost (both to the trimming and to the oil spill).

The ROV Beagle collects a Thesea rubra coral fragment. Image courtesy of Marine Applied Research and Exploration/ ROV Beagle.

When the ROV returns to the ship with its coral booty, humans take over. Researchers keep the coral branches at the right temperature and oxygen levels in plastic bins. They cut the coral into smaller pieces, peel away the outer polyp tissue from the skeletal base to prepare it for mounting and place each fragment in a glass vial. After several

hours of drying, they dab the fragment base with SeaTak, a nontoxic glue made from bivalves, and glue it into a concrete rack called a 'frag rack' that looks like a miniature apartment building for coral.

Within days (sometimes hours), a custom deep-sea 'elevator' (essentially an underwater platform with weights and floats), designed at NOAA's Southeast Fisheries Science Center, carries its precious cargo of coral fragments back down to their native depths. The ROVs then spread out the racks and take photos to monitor growth.

Working in the deep-sea makes everything more complicated. Operating a multimillion-dollar machine by remote control, pilots must navigate currents, avoid damaging corals and collect samples with the deftness of a surgeon, all while the ship above battles waves and wind.

'A lot of things can go wrong,' Jessie Heise, an ROV pilot and tech at University of North Carolina (UNC) Wilmington, told Mongabay. 'You're pretty much throwing a big piece of electronics into saltwater,' she said. The machine can be unwieldy at sea, and things break. Out at sea for sometimes more than a month, the techs have to think on their feet to fix any issues with only the equipment that's on board. 'We keep spares of everything.'

Technical divers monitor Swiftia exserta fragments one year after outplanting in the northern Gulf, off Pensacola, Florida, at a depth 213 feet. Image courtesy of Dave Whitting / NOAA.

May 2023 marked the first direct coral replanting. The team placed nearly 200 fragments of three species 230 feet below the surface. Monitoring shows survival rates between about 60% and 90% depending on coral species, fragment size and how close they are to other corals.

'Large fragments on hard substrate, under good conditions and close to other corals have a survivorship of 85-90%,' said coral expert Carlos Prada, assistant professor in the Department of Biological Sciences at the University of Rhode Island. He and his team checked the corals around 100 days after planting.

In 2024, the team planted 10 more coral racks (each holding 14 fragments) and continues to track their progress through regular monitoring missions.

Those tough Navy divers with the Mickey Mouse voices and other highly trained divers have also experimented with planting corals 'in situ' or in place, with the whole operation happening underwater. At depth, the divers fragment corals and use a special underwater glue to create frag racks in place.

So far, they have fragmented 56 corals directly on the seafloor. These haven't been monitored yet, so researchers aren't sure about their condition.

Technical divers Jake Emmert of Moody Gardens, an aquarium in Galveston, Texas, and Devin Waddell of the Georgia Aquarium reattach a coral colony (Swiftia exserta) to the reef in the northern Gulf. Image courtesy of Georgia Aquarium/Jonathan Langham.

With this method, too, planting coral in the deep is immensely difficult. These highly trained technical rebreather divers can't go below 100 m (328 ft), though they far surpass the recreational SCUBA diving limit of 40 m (130 ft). They can only spend around 20 minutes a day at such depths. Even that amount of time requires that divers spend a couple of hours in decompression before returning to the surface because high pressure causes nitrogen gas to dissolve in their blood and tissues and must be released slowly during ascent to prevent dangerous bubbles from forming.

To be safe, Gardner said, 'We're bringing hyperbaric chambers on every mission and getting some of the best doctors in the world to go with us that specialize in [diving].'

Breeding coral in labs

While field teams work out at sea, a parallel effort focuses on something never before attempted: growing deep-sea corals in laboratories. The idea is to breed corals on land, grow them to a sturdy size and plant them in the ocean.

This should enable laboratories to produce thousands of new corals for transplantation without needing to harvest fragments from wild corals.

To start the process, researchers brought fragments of three coral species (S. exserta, M. pendula and T. nivea) collected by the divers or ROVs to three federal labs built specifically for coral growth. NOAA labs in Galveston, Texas, and Charleston, South Carolina, and a USGS lab in Gainesville, Florida, house specialized systems designed to mimic the very specific conditions of the mesophotic zone.

The coral propagation lab at the USGS Wetland and Aquatic Research Center in Gainesville, Florida. Image courtesy of USGS.Swiftia exserta being fed in the lab. Image courtesy of NOAA.

The Audubon Aquarium in New Orleans also raises and displays these corals to visitors. In a back room not open to the public, aquarist Hillary Marzook stands amid the bubbling tanks under a red light. These animals require intensive care, she said: temperature and light controls, water chemistry management and a precise feeding regimen that mimics the downpour of food from the ocean above.

'They get a mix of frozen rotifers or baby brine depending on the polyp size,' Marzook said, as well as 'phytoplankton in a concentrated form and oyster eggs.'

Video footage from the Galveston lab shows a S. exserta colony feeding. A small pipette releases little brine shrimp around the corals. Each polyp's eight delicate orange and white tentacles reach, open and quickly close around the prey, a reminder that corals are indeed animals with an appetite.

These octocorals, so named for their eight tentacles per polyp, are completely predatory. They feed on organic material that flows past them on water currents, catching meals with their tentacles.Deep-sea coral species releases eggs in a laboratory aquarium, a first for deep-sea corals. Image courtesy of Will Jenkins/USGS.

'Anyone who's kept a saltwater aquarium knows how difficult it is,' said Gardner, who is part of the team that oversees operations at the labs. 'These corals are the next level of difficulty. A lot of work has been done with shallow corals, but for these mesophotic and deep, it's definitely a brave new world and these folks are on the cutting edge.'

Corals reproduce by releasing eggs and sperm into the water once a year. The fertilized eggs become tiny baby corals that drift in the water for days or weeks before settling on hard surfaces and wriggling into an ideal nook to grow. The team had to figure out how to control water temperature and lighting in the lab to encourage the deepwater corals to spawn.

In the Galveston lab, S. exserta have started reproducing, representing the first captive spawning of a mesophotic octocoral.

In 2023, these corals released approximately 50,000 eggs, which produced around 1,000 baby corals. 'Getting spawning and settlement in the lab is just super exciting,' Gardner said. 'We had corals spawn in our Galveston lab exactly one year apart to the day,' mimicking pattens in the wild.

Settlement tiles in the Galveston lab with newly recruited (baby) S. exserta coral polyps settled onto them. Image courtesy of NOAA.

Under these carefully maintained conditions, the corals are growing faster than expected. 'Instead of a centimeter a year, a centimeter every couple of months,' Gardner said in a livestream with NOAA, pointing out a colony that has nearly doubled in size over the past year.

None of the lab-grown corals have been brought back to the ocean, yet. Researchers want to better understand the genetics and ensure the corals reach a size that can survive in the wild. The first lab-to-ocean transplants are planned for later in 2025, a milestone that would mark a new chapter in marine restoration.

'We have over 1,800 now in the labs (most are new recruits reared in the lab),' Gardener said in an email, 'so our outplanting numbers should go up dramatically later this summer.'

Costs and challenges

Deep-sea restoration is as expensive as it is complex. For ROV operations alone, 'you're spending $10,000 a day, so you've got to know where to go,' Jason White, ROV pilot and operations manager for the Undersea Vehicles Program (UVP) at UNC Wilmington, told Mongabay. White helped the MDBC effort map coral sites and collect corals and other organisms from mesophotic and deep benthic ecosystems.

Lab work is also pricey. The coral propagation project started with $16 million just to build the facilities. This figure doesn't include the ongoing operational costs.

'It requires daily care, and it's usually at least two full-time people to run a coral lab, really more,' Gardener said. 'The ships and the vehicles that are required to get down to that depth are not insignificant.'

A diving bell is lowered from an MDBC expedition ship. Image courtesy of Sasha Francis / National Marine Sanctuary Foundation.

The project ran about 150 days of sea operations in 2023. In 2024, 14 missions on 10 different ships spent more than 200 days at sea, and 200 days are planned for 2025. All these missions require crews, technicians, researchers, staff and equipment. It adds up.

Although funding for the MDBC projects is covered through the BP oil spill settlement, recent staff cutsand contract backlogsacross NOAA are causing delays.

'Yeah, it's hurting us,' White said. Multiple missions have been postponed or canceled due to combinations of these issues. He said one ROV mission earlier this year was delayed because the project was unable to sign a contract to secure a vessel for operations, likely due to a backlog in approvalsfor new NOAA contracts.

Another mission was first delayed after a technical issue with the ship and then ultimately canceled when almost the entirety of the vessel's cruise schedule for the year was canceled due to staffing issues, White said.The contract issues prevented the project from hiring UVP personnel to work on another vessel.

'Would this have happened last year? No,' White said. 'It's been a huge impact.' These changes are 'definitely affecting the ROV operations,' he said, 'and this isn't just affecting our team. I know other entities that have lost jobs this year too.'

'It's NOAA's longstanding practice not to discuss personnel or internal management matters,' NOAA said to Mongabay in an email asking about these delays.

The long view

The current MDBC restoration effort is an eight-year initiative with three phases: a two-year planning stage (2020-22), a five-year implementation stage (2022-27) and a one-year final evaluation (2027-28), ending in 2028.

'A lot of this stuff is probably going to be longer than our lifetimes before we're seeing recovery, especially with the deep sea,' Gardner said.

Beyond the coral, the MDBC work is helping scientists better understand these deep-sea ecosystems. The projects have already yielded discoveries. Scientists have identified a new species of soft coral (Parasphaerasclera mcfaddenae) and a new deep-sea squat lobster as well as many other potentially new species such as sponges, snails and crinoids (sea lilies).Swiftia exserta is a species of coral found at mesophotic depths. It hosts an array of other species such as the brittle stars and crinoids shown here. Image courtesy of NOAA/ Oceaneering International, Inc.

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'Our scientists go out on the ships, and nearly every time they go down, they come up with something new,' Paul Mickle, co-director of the Northern Gulf Institute and an associate research professor at Mississippi State University, told Mongabay.

However, these highly diverse deep-sea ecosystems are under a great deal of pressure in the Gulf. Commercial bottom trawling continues physically destroying coral habitat, with heavy nets dragging across the seafloor. Some, but not all, of the coral restoration areas are in areas protected from trawling.

Agricultural runoff from the Mississippi River creates massive hypoxic 'dead zones' where oxygen-depleted water suffocates marine life. Climate change drives ocean acidification and warming, disrupting the delicate balance these ancient organisms need to survive.

'The 800-pound gorilla in the room is climate change and how it's changing things so quickly,' Larry McKinney, former director of the Harte Research Institute told Mongabay. McKinney, who led a team connecting academic researchers and on-the-ground government agencies in the wake of the Deepwater Horizon spill, warns that even the Gulf's remarkable resilience has limits.

Mesophotic corals and crinoids on Bright Bank, near the Flower Garden Banks National Marine Sanctuary, located 100 nautical miles off Galveston, Texas. Image courtesy of NOAA/Marine Applied Research and Exploration.

The threat of another major oil spill looms. Federal recordsshow that nearly 1,000 spills occurred in U.S. waters in 2021 and 2022 alone, releasing approximately 80,000 gallons of oil. While new safety requirements enacted after the Deepwater Horizon spill, like the well control rule,mandate specific equipment to prevent major blowouts, experts acknowledge that spills are inevitable in offshore drilling.

'It is essentially impossible to prevent all oil spills,' says a postfrom the New York-based advocacy nonprofit Natural Resources Defense Council. 'For the offshore oil and gas industry, they are simply a cost of doing business.'

The MDBC project is racing against these threats to learn about the deep sea and prioritize areas for protection. 'Knowing which areas are more susceptible to long-term damage than others,' Gardener said, helps set protection priorities, 'especially in the giant fields of 2000-year-old corals.'

'There needs to be some sort of spotlight on these animals, or no one's going to know about them,' Emch-Wei said, 'and therefore, no one's going to care.'

'I'm deeply concerned that we just don't know what they do for us,' Davies said of these underwater coral ecosystems, noting that we may lose them before we fully understand them. 'We need to understand the Earth. We need to understand the communities that live here. They deserve our respect. They deserve our attention.'

Banner image of lab-reared Swiftia exserta. Image courtesy of NOAA.

Liz Kimbrough is a senior staff writer for Mongabay and holds a Ph.D. in Ecology and Evolutionary Biology from Tulane University, in New Orleans, Louisiana where she studied the microbiomes of trees. View more of her reporting here.

15 years after the BP oil spill disaster, how is the Gulf of Mexico faring?

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